RANGSIT UNIVERSITY

มหาวิทยาลัยรังสิต

VIRTUAL REALITY AS AN ART EXHIBITION PLATFORM IN THE AGE OF PANDEMIC

BY

PIYANON SOMBOON

GOMESH KARNCHANAPAYAP

THIS RESEARCH IS SUBMITTED IN PARTIAL FULFILMENT OF

RESEARCH GRANT SPONSORED BY

RESEARCH INSTITUTE OF RANGSIT UNIVERSITY

2023

RANGSIT UNIVERSITY

มหาวิทยาลัยรังสิต

VIRTUAL REALITY AS AN ART EXHIBITION PLATFORM IN THE AGE OF PANDEMIC

BY

PIYANON SOMBOON

GOMESH KARNCHANAPAYAP

THIS RESEARCH IS SUBMITTED IN PARTIAL FULFILMENT OF

RESEARCH GRANT SPONSORED BY

RESEARCH INSTITUTE OF RANGSIT UNIVERSITY

2023

Title: VIRTUAL REALITY AS AN ART EXHIBITION PLATFORM IN THE AGE OF PANDEMIC

Researcher: Piyanon Somboon and Gomesh Karnchanapayap

Institution: Faculty of Digital Art, Rangsit University

Year of Publication: 2023

Publisher: Rangsit University

Sources: Rangsit University

No. of pages 68 pages

Keywords: Virtual Reality, Exhibition, Pandemic

ABSTRACT

Over the last two years, COVID-19 has changed practically everything. Unusual became normal. The pandemic has transformed our job, diet, and art. Exhibitions were the standard way to see, experience, and sell art. This mixed-methods study investigated photogrammetry as a method for 3D scanning art statues of King Bhumibol for use in a virtual reality art exhibition (virtual twin art exhibition), developed a virtual twin art exhibition based on the photogrammetry models, and evaluated its efficacy and viewer satisfaction. Photogrammetry was chosen for the 3D scanning the statues after consulting art, design, and technology experts. Forty-five exhibition-goers provided samples. Study tools included photogrammetry-based virtual reality art exhibition innovation, an in-depth interview, a customer satisfaction survey, and an innovation assessment. Qualitative data was analyzed. The findings show that 3D photogrammetry can create a realistic, immersive virtual art exhibition. The experts concluded that innovation should be rated highest overall. Finally, innovation satisfaction was the highest. During the pandemic, virtual twins might host high immersion and realism art shows.

ACKNOWLEDGEMENT

The researchers would like to express his deepest appreciation to Associate Professor Pakorn Prohmvitak, the advisor for his never-ending support on this research. Lastly, the researcher would like to thank all the audience and participants for their time in the interview.

PIYANON SOMBOON & GOMESH KARNCHANAPAYAP

RESEARCHERS

TABLE OF CONTENTS

		Page
ABSTRACT		c
ACKNOWLDGEMENT		d
TABLE OF CONTENS		e
LIST OF TABLES		g
LIST OF IMAGES		h
CHAPTER 1	**INTRODUCTION**	**1**
	1.1 BACKGROUND OF THE STUDY	1
	1.2 STUDY OBJECTIVES	2
	1.3 RESEARCH SAMPLES	2
	1.4 SIGNIFICANCE OF THE STUDY	2
CHAPTER 2	**LITERATURE REVIEW**	**3**
	2.1 PHOTOGRAMMETRY	3
	2.2 TECHNIQUES FOR CREATING 3D MODELS FROM PHOTOGRAPHS WITH PHOTOGRAMMETRY	4
	2.3 TYPES OF CAMERAS	5
	2.4 PHOTOGRAMMETRY PROGRAMS	6
	2.5 KING RAMA IX	9
CHAPTER 3	**RESEARCH METHODOLOGY**	**24**
	3.1 RESEARCH FRAMEWORK	24
	3.2 CONTENT SCOPE	24
	3.3 SAMPLES	24
	3.4 RESEARCH INSTRUMENTS	25
	3.5 DATA COLLECTION	25
	3.6 DATA ANALYSIS	25
	3.7 ETHICAL CONSIDERATIONS OF HUMAN RESEARCH	25

TABLE OF CONTENTS (CONT.)

		Page
CHAPTER 4	**RESULTS OF THE STUDY** ……..….	**26**
	4.1 PHOTOGRAMMETRY AS 3D SCANNING SOLUTION TO BE USED FOR VIRTUAL REALITY EXHIBITION…….	26
	4.2 THE PHOTOGRAMMETRY PROCESS…….	28
	4.3 EFFICACY AND VIEWER SATISFACTION OF KING BHUMIBOL' VIRTUAL TWIN EXHIBITION……	39
CHAPTER 5	**CONCLUSION** ……..….	**43**
	5.1 THE PHOTOGRAMMETRY APPROACH TO DIGITAL …… … RECREATION OF AN ART SCULPTURE ……...	43
	5.2 THE EFFICACY OF THE VIRTUAL EXHIBITION FROM …….. PHOTOGRAMMETRY ….....……..…….	43
	5.3 VIRTUAL EXHIBITION FROM PHOTOGRAMMETRY AS A …… SOLUTION FOR THE PANDEMIC ……	44
	5.4 CONCLUSION ……...	44
	5.5 RECOMMENDATIONS ……	44
BIBLIOGRAPHY …….….		**45**
APPENDIX	**RESEARCH TOOLS**	**48**
	A. RESEARCH QUESTIONNAIRE……. ……...……	**50**
RESEARCHER BIO……..….		**52**

LIST OF TABLES

Table		Page
1	Number of photos for the photogrammetry process and complexity of sculpture ..	35
2	Personal information of the samples	39
3	Ease of viewing the virtual exhibition.....	40
4	Levels of Immersion while viewing the virtual exhibition.....	41
5	Levels of Satisfaction after viewing the virtual exhibition.....	41

LIST OF IMAGES

Image		Page
1	Agisoft Metashape.....	7
2	Autodesk Recap Photo.....	7
3	3DF Zephyr	8
4	Reality Capture…….....	9
5	King Bhumibol Adulyadej visits his subjects.....	10
6	King Rama IX sharing his insights with Thai students	11
7	Notebook with front cover showing King Rama IX handing out books …….	12
8	King Bhumibol Adulyadej visited Mooban Jobakong on September 7, 1981 ……	13
9	King Bhumibol Adulyadej planting Maha Bodhi sappling at Deva Sankharam temple Kanchanaburi province on 26 October 1963 ……...	14
10	King Bhumibol Adulyadej anointing the white elephant Phra Swet Sura Kachatan on March 11, 1968 ……	15
11	Her Royal Highness Princess Maha Chakri Sirindhorn playing with the white elephant Phra Swet Sura Kachatan……	16
12	King Bhumibol Adulyadej and Phra Swet Sura Kachatan the white elephant. …….	17
13	King Bhumibol Adulyadej visiting Doi Pha Mee in 1971. ……	18
14	King Bhumibol Adulyadej and Somdet Phra Sri Nagarindra the princess mother. ...	19
15	King Bhumibol Adulyadej and Somdet Phra Sri Nagarindra the princess mother. ...	20
16	Somdet Phra Sri Nagarindra the princess mother clipping King Rama IX's hair …	21
17	King Rama IX and the 19th Supreme patriarch of the Buddhist monks……	22
18	Walt Disney welcoming Their Majesties during Disneyland visit in 1960 ……...	23
19	The royal family on Alice in Wonderland ride …….	23
20	RESEARCH FRAMEWORK ……	24
21	Canon EOS 5D Mark III ……	27
22	Canon EF 35mm f1.4L II USM …….	27

23	Placing bronze statues I……..	28
24	Placing bronze statues II ……	28
25	“The White Elephant and the King” …..……	29
26	“Mother’s Teachings” ……	29
27	“Two Dharma Kings” ……	30
28	“Bodhi of the Land” ……	30
29	“Gifts from the Sky”……..	30
30	“The Great King”……..	30
31	“The King’s Happiness” ……	31
32	“Protector of the Land”……..	31
33	Front view of “Regalis Vehiculum”……...	32
34	Opposing view of “Regalis Vehiculum”……	32
35	Camera Setting. ……..	32
36	Overlap shooting diagram. …….	33
37	Guide for shooting photogrammetry ……..	33
38	Photograph of “The White Elephant and the King” taken from the angle above the object …….	34
39	Photograph of “The White Elephant and the King” taken from the angle parallel to the object ……	34
40	Photograph of “The White Elephant and the King” taken from the angle below the object …….	34
41	Photos used in the photogrammetry project……...	35
42	Shadow and Highlight adjustment……..	35
43	Folder naming conventions ……...	36
44	The initial photogrammetry Result ……	36
45	Models which have been amended in ZBrush ……...	37
46	Scene UV editing in Autodesk Maya ……	37
47	Texture editing in Adobe Photoshop …….	37
48	Fully edited scene in Maya …….....	38
49	Virtual twin exhibition in Unreal Engine ……..	38

LIST OF IMAGES (CONT.)

Image		Page
50	The governor of Nan Province (third from left) presides over the opening of the exhibition ……..	39
51	Piyanon Somboon assists the audience viewing the VR exhibition …….	39

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

There is evidence, according to the World Health Organization (WHO), that the Coronavirus is most commonly spread between people who are in close contact with one another, typically within a distance of one meter. People can become infected with the virus through inhalation or through direct contact with nasal, ocular, or mouth aerosols and droplets that are carrying the virus (WHO, 2021). Prior to the outbreak of the pandemic, art venues were able to simultaneously accommodate a large number of guests. This is especially true with regard to well-known art institutions, which frequently experience high visitor volume levels. Because of the rapid spread of this epidemic, a great number of art institutions, galleries, and shows have been forced to close their doors out of fear that infected visitors will contract the potentially fatal illness. In this challenging situation, maintaining a social distance between one another is necessary in order to stay safe and reduce the risk of infection. This has a considerable impact on the overall landscape of the art world. Since the epidemic began, more than 85,000 art institutions have shut down, which accounts for 90% of the total number of closures (Guterres, 2020).

However, in order to make peace with this uncomfortable situation in the art world, a long-term solution for art displays that involve virtual reality might be possible. Despite the spread of the virus, virtual reality is seeing unprecedented growth (Diez, 2021). Virtual reality (VR) is now a part of our popular culture, as stated in the essay "Virtual Reality Will Be a Part of The Post-Pandemic Built World," which was published on Medium.com. The rise in the number of people working from home as a result of the epidemic has made people less dependent on their geographic location. The gap might be bridged with the use of virtual reality, which would also provide a new way of seeing artwork.

Assistant Professor Dr. Gomesh Karnchanapayap, one of the researchers, has created nine bronze statues that reflect the royal tasks that the late King Bhumibol Adulyadej carried out throughout his reign. These statues were cast in bronze. The sculptures were the primary focus of the research conducted for this study's analysis. Photogrammetry was utilized by the researchers so that the physical bronze statues could be converted into their digitally rendered realistic counterparts. It is generally agreed that Albrecht Meydenbauer, a German architect, was the first

person to use the term "photogrammetry" (Meydenbauer, 1867). Techniques drawn from a wide variety of academic fields, including as optics and projective geometry, are utilized in photogrammetry.

According to Suziedelyte-Visockiene et al. (2015), both the process of digital picture acquisition and photogrammetric processing involve many well-defined stages that ultimately lead to the formation of the object's 2D or 3D digital representations.

By utilizing photogrammetry, researchers will have the ability to digitally replicate bronze statues that are indistinguishable from their actual counterparts. Especially in times of pandemic, this has the ability to design a virtual display that is both secure and efficient.

1.2 STUDY OBJECTIVES

1.2.1 Investigate photogrammetry as a method for 3D scanning art statues of King Rama IX for use in a virtual reality art exhibition (virtual twin exhibition);

1.2.2 Create an innovative virtual twin art exhibition based on the photogrammetry models; and

1.2.3 Assess the viewer satisfaction of the virtual twin art exhibition.

1.3 RESEARCH SAMPLES

The samples consisted of forty-five exhibition attendees. On November 5, 2022, the show took place at the Erabica Art Gallery located at 36/1 Rangsikasem Road, Tambol Nai Wieng, Amphoe Meung, Nan Province. The samples were selected based on the following criteria using the volunteer sampling method: 1) Be interested in the topic of King Bhumibol Adulyadej's royal duties. 2) would like to try a new technique of art exhibition viewing.

1.4 SIGNIFICANCE OF THE STUDY

1.4.1 Understanding of audience factors in experiencing Art exhibition.

1.4.2 The body of knowledge of how to develop Virtual Reality exhibitions suitable as alternatives to traditional viewing method.

CHAPTER 2

LITERATURE REVIEW

The term "virtual reality" (VR) has become increasingly popular in recent years. In 1965, Ivan Sutherland was the one who came up with the very first concept for it. According to the research conducted by Morton Helig, five human senses contribute to human perception. These include the senses of sight (70%), hearing (20%), smell (5%), touch (4%), and taste (1%). According to Payatagool (2008), virtual reality (VR) is essentially a "fooling" of human senses that allows for an engaging and immersive experience within a simulated environment.

The epidemic caused by COVID-19 has irrevocably altered the way that many facets of our lives are lived. People can only visit art museums or exhibitions in a different capacity than they once did. Before the pandemic's outbreak, art venues could simultaneously accommodate a large number of guests. Because of the rapid spread of this epidemic, many art institutions, galleries, and shows have been forced to close their doors out of fear that infected visitors will contract the potentially fatal illness. In this challenging situation, maintaining a social distance between one another is necessary to stay safe and reduce the risk of infection. This has a significant impact on the overall landscape of the art world. Over 85,000 art institutions have shut their doors since the outbreak, responsible for 90 percent of the closures (Guterres, 2020). Because of this, VR is an excellent contender for the role of alternate platform for art display.

2.1 PHOTOGRAMMETRY

The creation of three-dimensional objects can be accomplished through a technique known as photogrammetry. According to Paisan Santithammanon's research from 2003, this method makes use of mathematical principles by locating points in a picture that are identical to one another and producing digital objects. The use of photogrammetry can be broken down into seven distinct facets, which are as follows.

1. A photographic procedure that uses instruments and processes that take place on the ground is called terrestrial photogrammetry. It makes use of a compact camera that is effortlessly movable and is frequently utilized for topographic mapping applications that are sufficiently specific, such as the mapping of mountainous terrain or mines.

2. Close-range Photogrammetry is a method for generating three-dimensional images at a distance from the camera; typically, the distance between the camera and the subject is between one and one hundred meters. This approach is frequently used in archaeological sites that call for a great deal of meticulous labor.

3. Macro Photogrammetry can be used to make miniature objects, which are frequently utilized for work in the medical or scientific fields, such as determining whether or not bone degradation has occurred.

4. Architecture Photogrammetry is the use of photogrammetry in surveying the measurements, materials, and structures of buildings for the purpose of documenting architectural data.

5. GPS photogrammetry, also known as aerial photographic surveying, involves flying in order to take images and receiving signals from a GPS device in order to locate a location at which to take pictures. It ensures that the values that were recorded are accurate. Most of its applications can be found at the Royal Thai Survey Department (ASPRS, 2000).

6. The practice of digital photogrammetry involves the use of mathematics to the processing of digital images along with the use of computer technology.

7. The use of softcopy surveys makes it possible for computer tools to be of assistance.

This study made use of digital photogrammetry in the form of digital photogrammetry, during which survey data were collected on sculptures and exhibition sites. The research was carried out in the United Kingdom.

2.2 TECHNIQUES FOR CREATING 3D MODELS FROM PHOTOGRAPHS WITH PHOTOGRAMMETRY

Creating 3D models from photographs of real-world items is known as photogrammetry. Computer processing is based on a two-dimensional image taken at an angle around the photograph's subject. A point cloud is a group of three-dimensional points that hold the value of the object's position in the X, Y, and Z axis coordinates for processing.

This procedure results in creating a 3D model by producing the surface and texture of the object. It brings the newly generated object extremely near to the original object, to the

point where the human eye cannot tell the difference between the genuine thing and the copied 3D model unless a digital comparison tool is used. It was discovered that the resolution in the point cloud system created with the photogrammetric method has a lower resolution than the resolution achieved when scanning items with 3D scanners.

Nevertheless, the cost of the instruments and equipment is less than that of scanning with 3D scanners, and the generated data or models are sufficient to be displayed. Application to a wide variety of 3D works, printing as real objects from 3D printers, researching and storing for use as a database, and printing as genuine objects from traditional printers. In Thailand, the application of such methods in research has yet to reach its full potential, particularly with regard to architectural research and the development of a city plan.

2.3 TYPES OF CAMERAS

In the field of photogrammetry, one of the most essential pieces of equipment is a camera. For the method to produce accurate and high-quality images, a camera of a very high quality is required.

2.3.1 Mirrorless Camera

In a mirrorless camera, the functions of a digital camera and a DSLR camera are combined (Saranee Sanguanruang, 2017). As a result, the image quality will be comparable to that of a DSLR camera, and the camera itself will be much smaller, lighter, and more compact. However, there will not be a mirror set at this point. As a direct consequence, the size of such a camera is more compact than that of a DSLR. Because it does not have a mirror set, the viewfinder needs to have a small LCD monitor fitted in it. However, in some versions, the LCD screen on the back of the camera will serve as the viewfinder instead of the traditional viewfinder. The following are some advantages of mirrorless cameras: In addition to their compact size, it offers image quality comparable to that of a DSLR camera, and it also possesses the ability to swap lenses, just like a DSLR. The drawback is that you are required to constantly glance at the LCD screen, which uses up more battery than it should. The response time is noticeably slower than that of a DSLR camera, and despite the fact that the quality is comparable, there is significantly more noise.

2.3.2 DSLR Camera

DSLR stands for Digital Single Lens Reflex. It operates similarly to a film camera in that light is allowed to go from the lens to the device's body. The light that would typically enter the lens is prevented from doing so by an oblique mirror. Mirror the image that is being seen in the viewfinder. The user will be able to look at the picture and then adjust the different hues of light before hitting the shutter button. The reflecting mirror will lift, allowing the light to travel to the sensor so that the image can be recorded. The quality of photographs taken with DSLR cameras is very excellent. The lenses are interchangeable, and many different accessories are available.

As a result, the researcher has decided to document their findings using a DSLR camera. Using photogrammetry technology to create a 3D model requires specialized software for picture processing and building and editing 3D models. The program will process this data from the photographs, and it will be used to construct a three-dimensional model that can be altered. Every program will come with its own unique set of benefits and drawbacks.

2.4 PHOTOGRAMMETRY PROGRAMS

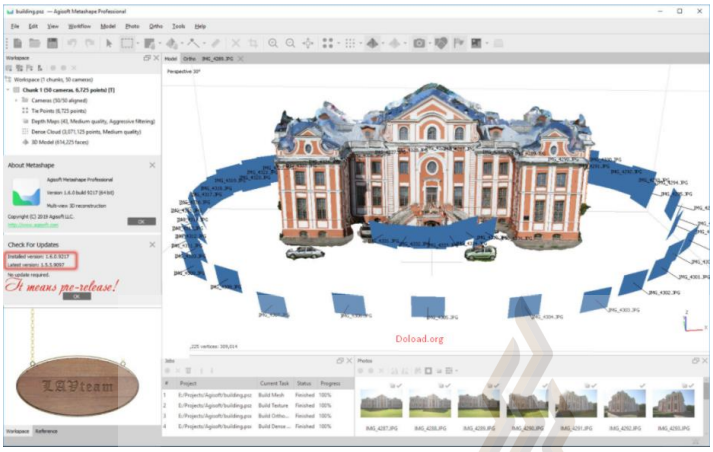
The tools Agisoft Metashape, Autodesk Recap Photo, 3DF Zephyr, and Reality Capture are among the most well-known in the field of photogrammetry. The researchers' findings and analyses of each program are presented in the following.

2.4.1 Agisoft Metashape

This piece of software employs the method of photogrammetry in order to transform 2D image data into 3D models. It is compatible with the output of cameras ranging from smartphones to DSLRs regarding image quality. The fact that this software offers high-precision work quality and displays exact features and colors of materials is the most crucial aspect of the software. It supports Windows, Mac OS X, and Linux operating systems, has a price tag of USD 3,499, and can use numerous GPUs to assist in data processing and collaborate with drones.

Figure 1

Agisoft Metashape



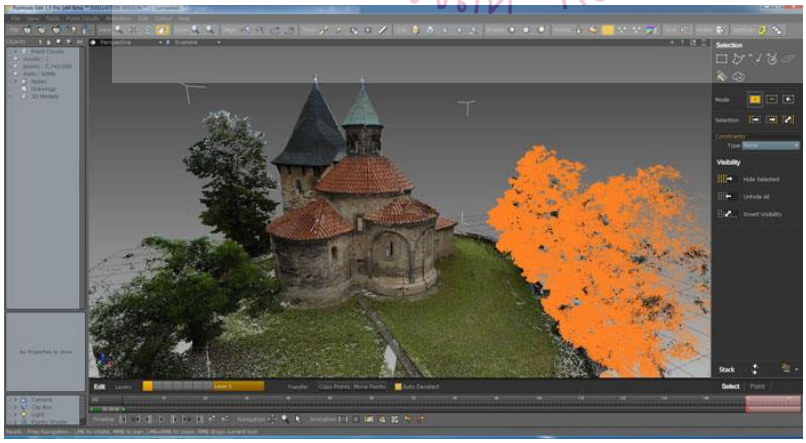
Note. Source: www.agisoft.com

2.4.2 Autodesk Recap Photo

This software was developed by Autodesk. It features additional capabilities, such as normal mode and the ability to work on the Cloud system. Autodesk Recap Photo is a photogrammetry technology that can process up to 1,000 images, which is an increase from the previous version's limit of 250 photographs that could be processed. This software is only compatible with the Windows operating system and costs 340 US dollars.

Figure 2

Autodesk Recap Photo



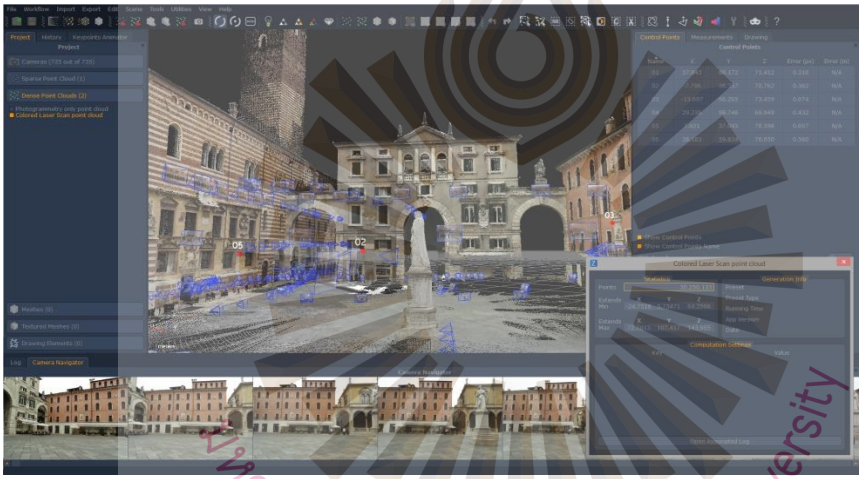
Note. Source: www.autodesk.com

2.4.3 3DF Zephyr

Another piece of software that employs photogrammetry in order to convert two-dimensional photos into three-dimensional models is this one. 3DF Zephyr is capable of extracting data from still images and moving images, and it comes with both a free trial version and a premium one. Users also have the ability to modify the processing resolution. It is able to save files in OBJ PLY and FBX formats respectively. The software can only run on computers running the Windows operating system and costs $4,400 USD.

Figure 3

3DF Zephyr



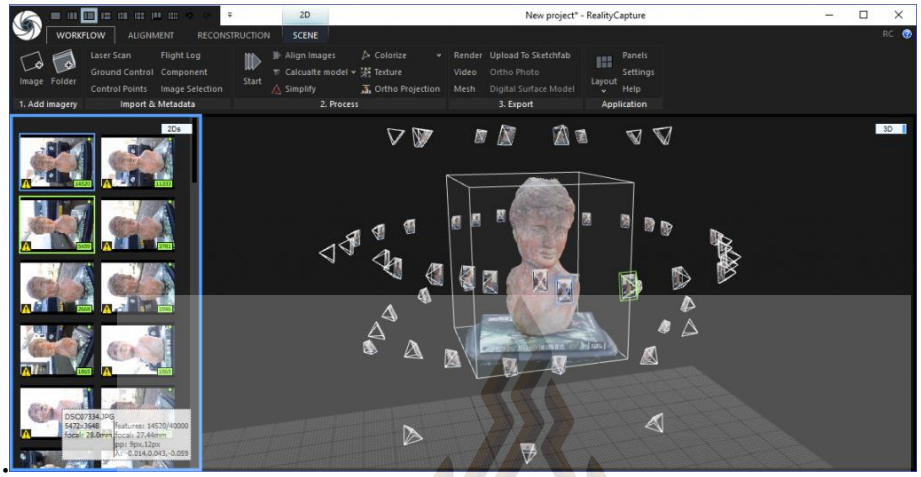
Note. Source: www.3dflow.net

2.4.4 Reality Capture

The software Reality Capture is used for image processing and creating three-dimensional models from two-dimensional photographs. If desired, the file can be saved or viewed in a different program once the processing is complete. Inspecting the final product is possible using both a point cloud display and a material texture display. The resulting file formats are FBX, OBJ, and XYZ. The lack of associated costs is one of the advantages of utilizing this method. However, you only pay for it when you export the model, which is a significantly lower cost than the other applications listed previously.

Figure 4

Reality Capture



Note. Source www.capturingreality.com

In conclusion, each of the four photogrammetry software programs that were discussed has both strengths and drawbacks, and selecting one over the other depends on the project's specific objectives, budget constraints, and the operating system's compatibility. Agisoft Metashape and Autodesk Recap Photo are well-rounded systems that balance pricing and the number of functions offered. Similarly, the concentration of 3DF Zephyr on picture and motion data can make it an appealing choice for some applications. The one-of-a-kind pricing structure and variety of export possibilities provided by Reality Capture may appeal to those whose requirements are exact. Reality Capture was the program that the researchers decided to use as the principal tool for carrying out photogrammetry operations.

2.5 KING RAMA IX

The subject for testing this research project is an art exhibition by Assistant Professor Dr. Gomesh Karnchanapayap, whose works are about King Bhumibol Adulyadej.

King Bhumibol Adulyadej, or King Rama IX, was the ninth king of the Chakkri dynasty between 1950-2016. His Majesty King Bhumibol Adulyadej of Thailand was born on Monday, December 5th, 1927, in Cambridge, Massachusetts, United States of America, as the third and youngest child of Their Royal Highnesses Prince and Princess Mahidol of Songkhla ("Biography of His Majesty King Bhumibol Adulyadej," 1999). As monarch, King Rama IX

enjoyed immense popularity among his subjects through his various beneficial projects and philosophical teachings. (Augustyn, 2021). Thus, the researchers would like to take the King's great deeds as the critical ingredients for art creation to carry on a legacy of his achievements through visual arts.

2.5.1 King Bhumibol the Great

Dr. Karnchanapayap, the researcher, used to hear about the King's projects and how they improved the lives of Thai citizens on a daily basis when he was younger. As seen in figure 5, his dedication, hard labor, and concern for Thai people were visible in daily news reports at the time. In the researcher's view, His Majesty the King deserves to be called "paternal monarch" for his great devotion and unbounded love toward his subjects.

Figure 5

King Bhumibol Adulyadej Visits His Subjects

Note. Source: www.nationtv.tv

2.5.2 The King and Thai Education

Since coronation, His Majesty King Bhumibol Adulyadej (Rama IX) has taken on the difficult duty of ensuring the welfare and livelihood of his subjects throughout the land. As shown in Figure 6, his majesty always eager to share his knowledge with Thai students. One may say knowledge and rights to education for citizens within his kingdom were his priorities. ("King Rama IX and Thai Education," 2019)

Figure 6

King Rama IX Sharing His Insights with Thai Students

Note. Source: www.nationtv.tv

King Rama IX said on July 27, 1981 in a speech about education. "Education is a fundamental ingredient in establishing and developing knowledge, moral values of the individuals in a nation. If a nation provides a good and sufficient education to its youth, [that nation] will have

strong citizens to progress further". King Rama IX aimed to improve the nation's education at all levels from school education system, self-education, to remote learning in all areas of Thailand ("King Rama IX and Thai Education," 2019).

To accelerate the process, His majesty King Rama IX visited rural areas where education resources were scarce and provided books, stationaries, and fundings as shown in Figure 7.

Figure 7

Notebook with Front Cover Showing King Rama IX Handing Out Books

Note. Source: www.thamwiwat.com

2.5.3 The King and Land Rover Series III

King Rama IX made a promise to promote the welfare of all his subjects during his coronation ceremony on May 5, 1950 with the speech "We shall reign with righteousness for the benefits and happiness of the Siamese people". Throughout his reign, he has kept his word, and no

distance is too far for him to travel to see his subjects. On 7 September 1981, King Rama IX visited a rural area of Mooban Jobakong Tambol Pooyo Amphoe Sungai Kolok Narathiwat Province with Land Rover Series III. His majesty King Rama IX requested the driver to stop atop a wooden bridge and ask Mr.Prom Jindabud, a local in the area regarding the village and its problems as shown in Figure 8. During his visit to the area, the King would work relentlessly to alleviate his subjects' sufferings ("Land Rover Series III: From His Majesty King Rama IX's vehicle to Piggy Bank "Follow Father's Steps"," 2017).

Figure 8

King Bhumibol Adulyadej Visited Mooban Jobakong on September 7, 1981

Note. Source: www.thairath.co.th

2.5.4 The King and Reforestation

King Rama IX was a visionary who prioritized forestry as a national priority. He feared that irresponsible deforestation could result in a national crisis. Land, on the other hand, may be healed with appropriate design and execution (Karnjanatawe, 2017). Those who followed royal news would notice King Rama IX frequently visiting his subjects in drought-stricken

districts of the kingdom (Saosawadee, 2016). Many royal projects are devoted to reviving woods and ensuring that the land remains productive for future generations. Shown in Figure 9, on 26 October 1963, King Rama IX visited Deva Sankharam temple in Kanchanaburi province and planted Maha Bodhi Tree sapling (Posttoday, 2016).

Figure 9

King Bhumibol Adulyadej Planting Maha Bodhi Sappling at Deva Sankharam Temple Kanchanaburi Province on 26 October 1963

Note. Source: mgronline.com

2.5.5 The King and the Young White Elephant

According to Thai's traditional belief which is an amalgamation of Brahma-Hindu and Buddhism, Elephants especially white elephants are considered auspicious creatures that bring. (Ampanwong, 1994). During the reign of King Bhumibol Adulyadej there were 21 white elephants. The royal elephant in the figure 10 was named "Phra Swet Sura Kachatan

Baromnarueban Swamipak Suphaluknatreatikhun Tossakulvisitprompongsa Adulyawongtamapahattee Prachachanasawadeevibul Sakakarasiammanatsurapahon Mongkollerdfah". The white elephant was discovered in Tambol Balor Amphoe Raman Yala Province and was presented to the king on March 9, 1968 and anointed as the King's subject on March 11, 1968.

Figure 10

King Bhumibol Adulyadej Anointing the White Elephant Phra Swet Sura Kachatan on March 11, 1968

Note. Source: prachachat.net

Figure 11

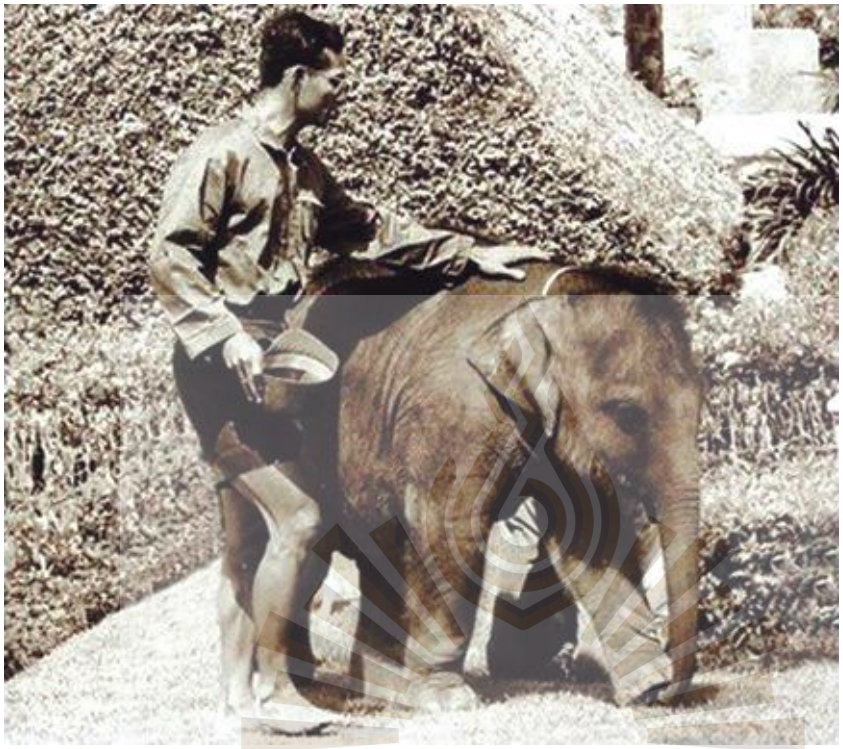
Her Royal Highness Princess Maha Chakri Sirindhorn Playing with the White Elephant Phra Swet Sura Kachatan

Note. Source: www.tnews.co.th

The young white elephant was also a good friend of Her Royal Highness Princess Maha Chakri Sirindhorn (Figure 11) and often accompanied the princess to Klai Kang Won Palace. (Sitthisankij, 2007)

Figure 12

King Bhumibol Adulyadej and Phra Swet Sura Kachatan the White Elephant.



Note. Source: www.naewna.com

The researchers believe the white and King Bhumibol Adulyadej developed a special bond as shown in Figure 12 depicting the close relationship between the two. The photograph was able to capture the King's mercifulness which extended to creatures of his land.

2.5.6 His Majesty's Quest to Improve the Livelihood of His Subjects

King Rama IX truly held on to his promise "We shall reign in righteousness for the benefits and happiness of Siamese people" given on 5 May 1950. In fact, no one in Thailand's history has done more to enhance the lives of its citizens than His Majesty King Bhumibol Adulyadej. Thousands of development initiatives have been launched by him, all of which have helped the country and its people significantly (Wechsler, 2014). Take, for example, Doi Pha Mee village in northern Thailand, where the coffee goods are the outcome of His Majesty's efforts to improve the lives of his people. Pha Mee, which literally means "Bear Mountain," is an Akha tribe community located in the northern Thai province of Chiang Rai (Roxas, 2017). The villagers were

dealing with poverty in the early 1970s, and they had to turn to producing opium to make ends meet. Fortunately, thanks to King Rama IX's assistance, Pha Mee village has been transformed into a habitable and pleasant community. Figure 13 shows King Rama IX riding on a donkey during his visit to Doi Pha Mee in 1971. He then formed a concrete plan to improve the land and visited the village again to put the plan in action in 1973 and 1974. The King is reported to have studied the area and advised them to cultivate coffee, which they still do today (Valentina, 2017).

Figure 13

King Bhumibol Adulyadej Visiting Doi Pha Mee in 1971.

Note. Source: www.isranews.org

2.5.7 His Majesty King Rama IX's Filial Piety

King Rama IX's devotion for his mother, Somdet Phra Sri Nagarindra, the princess mother, is another well-known attribute. Photographs depicting their intimate bond revealed his gestures of filial piety (Sumamanon, 2017). Figure 14, 15, and 16 show photographic records of King Bhumibol Adulyadej and Somdet Phra Sri Nagarindra the princess mother.

Figure 14

King Bhumibol Adulyadej and Somdet Phra Sri Nagarindra the Princess Mother.

Note. Source: www.chiangmaicitylife.com

Figure 15

King Bhumibol Adulyadej and Somdet Phra Sri Nagarindra the Princess Mother.

Note. Source: www.thairath.co.th

Figure 16

Somdet Phra Sri Nagarindra the Princess Mother Clipping King Rama IX's Hair

Note. Source: www.khaosod.co.th

2.5.8 King Rama IX and Buddhism

His majesty King Rama IX is a firm believer and a devotee of Buddhism. His benevolence and kindness have been evident in all the activities he has been involved with. He became an exemplary of a just monarch and a protector of Buddhism. Since his accession to the throne on June 9, 1950, His Majesty the King has followed the ten royal rules (Dhosapit Raja Dhamma). During his reign, he often seek out wisdom from noble monks ("Noble Monks and King Rama IX," 2016). Figure 17 shows King Rama IX and the 19th Supreme patriarch of the Buddhist monks.

Figure 17

King Rama IX and the 19th Supreme Patriarch of the Buddhist Monks

Note. Source: mgronline.com

2.5.9 Royal Family Visiting Disneyland

Their Majesties King Bhumibol Adulyadej and Queen Sirikit paid a historic visit to the iconic Californian amusement park Disneyland in 22 June 1960, while on an official state visit to the United States. Shown in figure 18, Walt Disney personally welcomed Their Majesties, as well as Prince Vajiralongkorn and Princess Ubol Ratana Rajakanya ("Documentary of the first official visit to the United States of His Majesty King Bhumibol Adulyadej in 1960," 2016).

Figure 18

Walt Disney Welcoming Their Majesties during Disneyland Visit in 1960

Note. Source: www.pptvhd36.com

Figure 19

The Royal Family on Alice in Wonderland Ride

Note. Source: www.matichon.co.th

The researcher would like to make nine sculptures based on the aforementioned results after examining his Majesty King Rama IX's life.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 RESEARCH FRAMEWORK

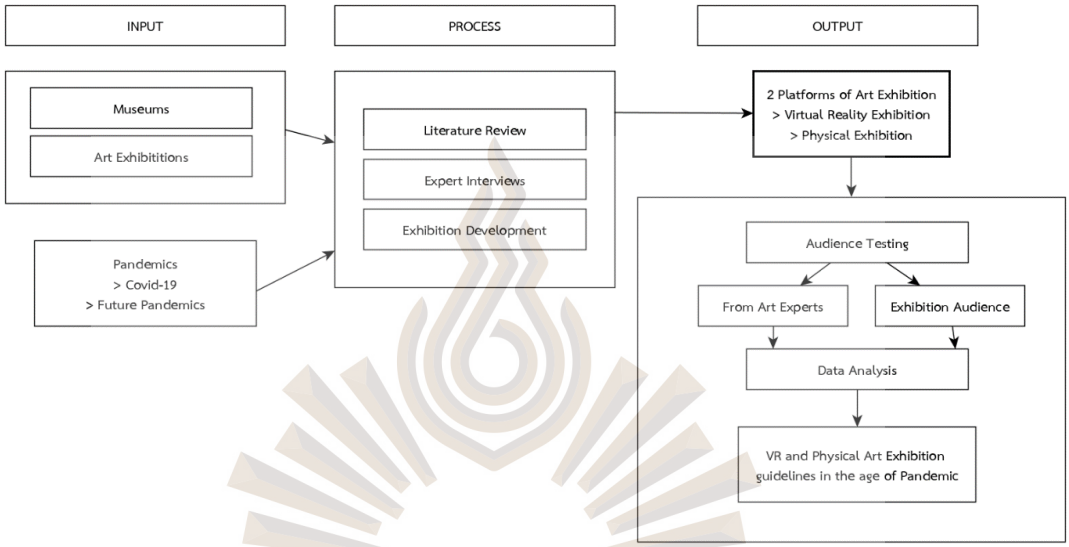


Figure 20 Research Framework

3.2 CONTENT SCOPE

The researcher would like to use this study to produce traditional and virtual reality art exhibitions on the topic of King Rama IX.

3.3 SAMPLES

The samples consisted of forty-five exhibition attendees. On November 5, 2022, the show took place at the Erabica Art Gallery located at 36/1 Rangsikasem Road, Tambol Nai Wieng, Amphoe Meung, Nan Province. The samples were selected based on the following criteria using the volunteer sampling method: 1) Be interested in the topic of King Bhumibol Adulyadej's royal duties. 2) would like to try a new technique of art exhibition viewing.

3.4 RESEARCH INSTRUMENTS

The research tools included a virtual reality art exhibition innovation created using a photogrammetry technique, an expert interview, an innovation evaluation form, and a satisfaction form. Content analysis was used to examine qualitative data.

3.5 DATA COLLECTION

The following were the steps in data collection. The methods for developing the research tools were discussed as follows:

3.5.1 Three experts in the fields of art, design, and technology were asked to come to a structured interview session to share their insights about how photogrammetry could be used to make virtual art objects based on their real-world counterparts.

3.5.2 The virtual reality exhibition from photogrammetry was shown at the show, and then attendees filled out a questionnaire about how well it worked as a possible alternative to a physical exhibition and how satisfied they were with what they experienced.

3.6 DATA ANALYSIS

A review of the expert interview sessions was done in order to identify which photogrammetry method would be the most effective when it comes to creating digital models from bronze statues. The innovation's validity was examined by three industry leaders, who collectively arrived at an IOC score of 0.90. The industry professionals' comments and suggestions were considered while we worked to perfect the idea. In addition, the validity of the user satisfaction form was analyzed by three industry professionals with an IOC of 0.85.

3.7 ETHICAL CONSIDERATIONS OF HUMAN RESEARCH

This article is a report on the study that was conducted under the title "Virtual Reality as an Emerging Art Exhibition Platform in the Age of Pandemic," which was approved by the Ethics Review Board of Rangsit University and given the permission number RSUERB2021-053 on its Certificate of permission.

CHAPTER 4

RESULT OF THE STUDY

The results were presented according to the research objectives as follows:

4.1 PHOTOGRAMMETRY AS 3D SCANNING SOLUTION TO BE USED FOR VIRTUAL REALITY EXHIBITION

The researchers asked in-depth questions to three different specialists in their respective fields: Assistant Professor Thammasak Aueragsakul, an experienced digital artist and faculty member at Digital Arts Rangsit University; Assistant Professor Paniti Keowsawat, a technology expert and faculty member at the Faculty of Information Technology Phetchaburi Rajabhat University; and Professor Wattana Jutavipard, a well-known designer. The researchers then decided to conduct an in-depth investigation into the technique of photogrammetry, from which they drew their conclusions regarding the computer equipment and software required to create and implement the virtual exhibition innovation.

4.1.1 The camera for photogrammetry

The Canon EOS 5D Mark III (Figure 21) was the camera the researchers used. This particular model has a full-frame sensor and 22.3 megapixels. Because the ISO sensitivity of this camera model can be adjusted from 100 all the way up to 25,600, and it can even be pushed all the way up to 102,400, it is suitable for the activities that are required by this research. The EF Mount L-Series Lens with a Full-Frame Format was the primary lens that was utilized for this research and is seen in Figure 22.

Figure 21

Canon EOS 5D Mark III

Note. By the authors

Figure 22

Canon EF 35mm f1.4L II USM

Note. By the authors

4.1.2 The software for photogrammetry

Reality Capture by Epic Games is one of the leading photogrammetry programs on the market, even though there are many other photogrammetry programs available. This is because it comes pre-loaded with all of the necessary capabilities. (CapturingReality, 2022) Some of its features include image registration (alignment), automatic calibration, polygon mesh calculation, coloring, texturing, parallel projections, georeferencing, DSM, coordinate system conversion, simplification, scaling, filtration, smoothing, measurement, inspection, and multiple exports and imports. Consequently, the researchers decided what kind of software to use for this investigation. When it came to modifying UVs, the researcher relied on AutoDesk Maya. In order to edit the forms of the models, Maxon ZBrush was used. In order to make alterations to the photos, Adobe Lightroom was employed. When altering textures, Adobe Photoshop was the program of choice.

4.1.3 The software for creating virtual exhibition

The researchers chose the Unreal Engine, which is free and can export content for viewing in a virtual reality headset, to create a virtual exhibition experience. The version used in this research is Unreal Engine 5.1.

4.1.4 The hardware to run the virtual exhibition

The researchers ran the study on a 64-bit version of Windows 10 with 16 GB of RAM and an nVidia GeForce GTX 1080 graphics card. The personal computer is a VR-ready notebook, which means it can play the experience via a virtual reality head-mounted display. The virtual reality headset used for this study was Oculus Rift-S.

4.2 THE PHOTOGRAMMETRY PROCESS

To acquire the best photogrammetry results possible, the following steps were taken.

4.2.1 Placing Sculptures in the exhibition setting

Placing the sculptures in position, according to the actual exhibition plan, with complete lighting, so that when the models are scanned using photogrammetry, they will have the correct light and shadow (Figure 23-24).

Figure 23

Placing bronze statues I

Note. Asst. Prof. Dr. Gomesh Karnchanapa yap begins putting statues in place at Erabica Art Gallery on 18th January 2022. Own work.

Figure 24

Placing bronze statues II

Note. Piyanon Somboon checks on the lightings of the exhibition at Erabica Art Gallery on 18th January 2022. Own work.

4.2.2 Assess complexity of the object to photogrammetry

The planning of photogrammetry is influenced by both the exhibition's format and its art works. For this study, researchers categorized as follows:

1. Environment and exhibition space

The researchers must take photographs of the entire surrounding space, including the floor, walls, paintings on the wall, and ceiling, which will then be digitally reproduced.

2. Bronze sculptures

Each piece of sculpture on show has a varied level of complexity, which can be categorized as flow, medium, and high complexity sculptures.

Low complexity sculptures are works with objects or figures fewer than two. There are four sculptures in this category. “The White Elephant and the King” (Figure 25) depicts King Rama IX petting the juvenile royal white elephant. “Mother’s Teachings” (Figure 26) depicts Somdet Phra Srinagarindra Boromarajajonani, the King’s mother, cutting King Rama IX’s hair.

Figure 25

“The White Elephant and the King”

Note. Bronze statue created by Asst. Prof. Dr. Gomesh Karnchanapayap. Own work.

Figure 26

“Mother’s Teachings”

Note. Bronze statue created by Asst. Prof. Dr. Gomesh Karnchanapayap. Own work.

“Two Dharma Kings” (Figure 27) depicts King Rama IX walking alongside the 19th Supreme Patriarch of Thailand. "Bodhi of the Land" (Figure 28) depicts a seated King Rama IX planting a Bodhi sapling on the ground in the shape of a map of Thailand.

Figure 27

"Two Dharma Kings"

Note. Bronze statue created by Asst. Prof. Dr. Gomesh Karnchanapayap. Own work.

Figure 28

"Bodhi of the Land"

Note. Bronze statue created by Asst. Prof. Dr. Gomesh Karnchanapayap. Own work.

Medium complexity sculptures are works with three objects or figures. There are two sculptures in this category. "Gifts from the Sky" (Figure 29) depicts King Rama IX handing a notebook to a young schoolgirl who positions herself next to a teacher holding a royal gift bag. "The great king" (Figure 30) is a set of three bust statues of King Rama IX with wooden bases.

Figure 29

"Gifts from the Sky"

Note. Bronze statue created by Asst. Prof. Dr. Gomesh Karnchanapayap. Own work.

Figure 30

"The Great King"

Note. Bronze statue created by Asst. Prof. Dr. Gomesh Karnchanapayap. Own work.

High complexity sculptures contain more than three objects or figures. There are three sculptures in this category. "The King's Happiness" (Figure 31) depicts the royal family; King Rama IX, Queen Sirikit, Princess Ubolratana Rajakanya, and Prince Vajiralongkorn —in a Disney

ride. “Protector of the Land” (Figure 32) depicts King Bhumibol Adulyadej seated on a mule, with the hill tribe leader walking ahead. There are courtiers on both the left and right sides.

Figure 31

“The King’s Happiness”

Note. Bronze statue created by Asst.Prof. Dr. Gomesh Karnchanapayap. Own work.

Figure 32

“Protector of the Land”

Note. Bronze statue created by Asst.Prof. Dr. Gomesh Karnchanapayap. Own work.

“Regalis Vehiculum” (Figures 33 and 34) displays His Majesty King Bhumibol Adulyadej the Great Borommanatbophit squatting and leaning on the left side of the Royal Land Rover Series III or "Series Three" Long Wheel Base model, with a villager squatting and providing information. Two courtiers sat in front of the royal car, while a royal guard positioned on the right side of the vehicle.

Figure 33

Front view of “Regalis Vehiculum”

Note. Bronze statue created by Asst. Prof. Dr. Gomesh Karnchanapayap. Own work.

Figure 34

Opposing view of “Regalis Vehiculum”

Note. Bronze statue created by Asst. Prof. Dr. Gomesh Karnchanapayap. Own work.

4.2.3 Photographing the bronze sculptures

The images in this research were captured with a 35mm lens with an aperture range of F8–F11 and a tripod to prevent camera shake. Avoid using a high ISO level to brighten the image, since this can increase digital noise and diminish image detail. The White Balance setting should not be set to "Auto," as it may result in varying color temperatures in each photograph. RAW files are image data captured by the camera's image sensor without compression or reduction, resulting in high-quality images that take advantage of the camera's capability to the fullest extent. See Figure 35. for the camera settings.

Figure 35

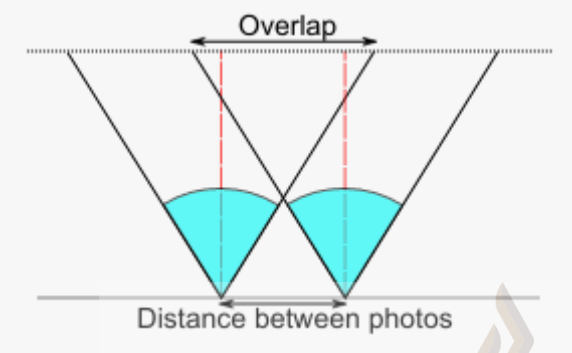
Camera Setting.

Note. By the authors

As seen in Figure 36, photography must be taken around the sides of the object and overlap each other. To avoid depth of field, the photographer must not adjust the focal length throughout the entire session

Figure 36

Overlap shooting diagram.



Note. The diagram depicting a guide for shooting an object by overlapping corners. From www.drewsilcock.co.uk, by Drew Silcock, 2014.

Figure 37

Guide for shooting photogrammetry

Note. The diagram depicting a guide for shooting an object at different angles and all around the object. From Photogrammetry - Advanced Capture, by CINE Communities. (n.d.)

The following are extra factors to consider when capturing photographs (Figure 37).

1. The photographer must capture each side of the object from three separate perspectives: above the object, parallel to the object, and below the object.

2. Shoot in a complete circle with the subject at the center, overlapping the previous image by approximately 50 percent.

3. Take close-up photographs to capture the object's fine details.

Figure 38

Photograph of "The White Elephant and the King" taken from the angle above the object

Note. Photo taken at Erabica Art Gallery on 18th January 2022. Own work.

Figure 39

Photograph of "The White Elephant and the King" taken from the angle parallel to the object

Note. Photo taken at Erabica Art Gallery on 18th January 2022. Own work.

Figure 40

Photograph of "The White Elephant and the King" taken from the angle below the object

Note. Photo taken at Erabica Art Gallery on 18th January 2022. Own work.

Figures 38-40 depict three different shooting angles from one side of an object. Taking the complexity of the object into consideration, the photographer should take as many images as possible from all sides so that the program can efficiently calculate the surface. For the environment, the researchers must take the entire surrounding area of the exhibition of 2,171 shots. The entire project requires a total of 3,391 photos (Figure 41). Table 1 shows the number of photos for each sculpture and the exhibition environment.

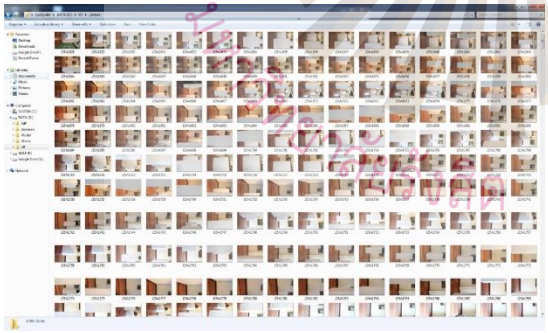
Table 1

Number of photos for the photogrammetry process and complexity of sculpture

Sculpture Title	Complexity	Above	Parallel	Below	Close-up	Total
The White Elephant and the King	Low	16	20	13	36	85
Mother's Teachings	Low	15	20	23	28	86
Two Dharma Kings	Medium	23	35	17	26	101
Bodhi of the Land	Medium	34	25	15	29	103
Gifts from the Sky	Medium	22	35	42	27	126
The Great King	Medium	46	47	56	28	177
The King's Happiness	High	24	37	42	39	142
Regalis Vehiculum	High	40	36	53	69	198
Protector of the Land	High	44	42	45	71	202
Total						1220

Figure 41

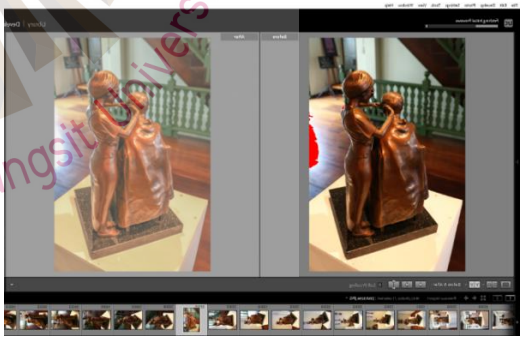
Photos used in the photogrammetry project



Note. 3,391 photos were taken for the photogrammetry. Own work.

Figure 42

Shadow and Highlight adjustment



Note. Adjustments done in Adobe Light Room. Own work.

4.2.4 Adjust the photographs

In order to see the intricacies of both the dark and bright areas of the image, reduce shadow and highlight in all photos using the photo editing software as shown in Figure 42.

4.2.5 Create 3D models with RealityCapture

Importing all photos into the RealityCapture application is the next step. Two sets of photographs must be imported: the set to be processed as a model and the set to be processed as a texture. Put them in separate files and give them the following names: "_geometry" and "_texture" as indicated in Figure 43, so that the application can identify which group of photos is for 3D model processing. Both image sets are similar, but the "_geometry" set contains photos with shadow and highlight adjustments, as shown in Figure 44, to improve the performance of the model computation algorithm.

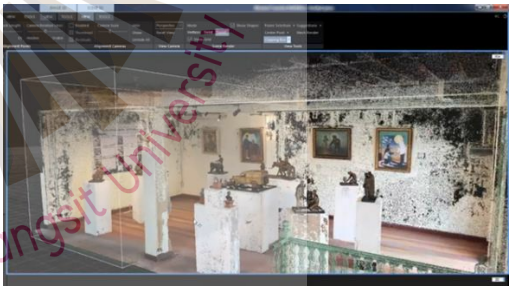
Figure 43

Folder Naming Conventions

Note. Folders were named “_geometry” and “-texture” respectively.

Figure 44

The Initial Photogrammetry Result



Note. The generated models are often partially imperfect and contain opening faces shown in black. Own work.

4.2.6 Initial results from Reality Capture

Reality Capture relied on the numerous photos to create 3D models, the results often contain imperfections such as holes which are shown in black (Figure 43).

4.2.7 Improve the photogrammetry model quality

Due of the imperfect outputs of photogrammetry, the models cannot be utilized directly. Therefore, the researchers must modify the model in the Zbrush program. To be reused in RealityCapture again, the model's exported coordinates must remain unchanged. Figure 45 displays the outcomes of the revised models.

Figure 45

Models which have been amended in ZBrush

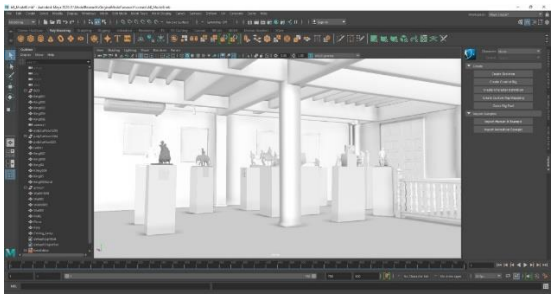
Note. Maxon ZBrush was used to correct imperfections from photogrammetry. Own work.

4.2.8 Create UV and texture for the photogrammetry models

Researchers unwrapped UV in Maya (Figure 46) and transferred it back to texture in RealityCapture. Again, some of the textures were poor, requiring some Photoshop editing (Figure 47). The Maya scene which has been fixed is shown in figure 48.

Figure 46

Scene UV editing in Autodesk Maya



Note. Screenshot directly in Autodesk Maya. Own work

Figure 47

Texture editing in Adobe Photoshop

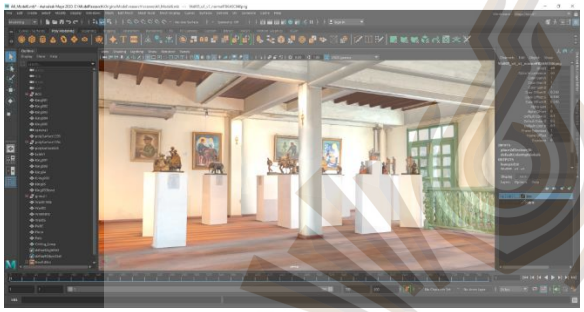
Note. Screenshot directly in Adobe Photoshop. Own work.

4.2.9 Assemble the virtual reality experience

Take all models and textures in Maya and export them to Unreal Engine 5.1 as OBJ files. By placing all models in a scene and configuring the model's position and size to match the physical exhibition as closely as possible, we will achieve the realistic VR viewing experience possible as virtual twin exhibition (Figure 49).

Figure 48

Fully edited scene in Maya



Note. Screenshot directly in Autodesk Maya. Own work.

Figure 49

Virtual twin exhibition in Unreal Engine

Note. Screenshot directly in Unreal Engine Own work.

4.2.10 The exhibition

The researchers held the exhibition on 5th November 2022 on the upper floor of the Erabica Art Gallery. The opening ceremony was presided by the Governor of Nan province (Figure 50). Figure 51 depicts how an audience experiences the virtual exhibition by donning a VR head-mounted display tethered to the notebook.

Figure 50

The governor of Nan Province (third from left) presides over the opening of the exhibition

Figure 51

Piyanon Somboon assists the audience viewing the VR exhibition

4.3 EFFICACY AND VIEWER SATISFACTION OF KING BHUMIBOL' VIRTUAL TWIN EXHIBITION

4.3.1 Statistical data of the samples

The personal information of the samples is shown in Table 1 below:

Table 2

Personal information of the samples

No.	Personal Information	Frequency (n=45)	Percentage (%)
1	Sex		
	Male	24	53.3
	Female	22	48.9
2	Age range		
	15-20	14	31.1
	21-30	7	15.5
	31-40	6	13.3
	41-50	12	26.6
	51-60	4	8.8
	61-70	1	2.2
	>70	1	2.2

As shown in Table 2, 53.3% of the 45 people that attended the exhibition were males, while 48.9% were females. Attendees ranged in age from 15 to 20 years old (31.1%), 41 to 50 years old (26.6%), 21 to 30 years old (15.5%), 31 to 40 years old (13.3%), 51 to 60 years old (8.8%), 61 to 70 years old and older than 70 years old are tied (2.2%).

4.3.2 Ease of viewing the virtual twin exhibition

The researcher used a Likert scale to assess the opinions of the samples regarding the simplicity of viewing the virtual display. 21 participants (46.7%) chose "easy to use", 18 participants (40%) selected "very easy to use", and 6 participants (13.3%) voted "neutral" as shown in Table 3.

Table 3

Ease of viewing the virtual exhibition

Likert Scale	Frequency (n=45)	Percentage (%)
Extremely difficult to use	0	0
Difficult to use	0	0
Neutral	6	13.3
Easy to use	21	46.7
Extremely easy to use	18	40

4.3.3 Level of immersion while viewing the virtual twin exhibition

The researcher used a Likert scale to assess the opinions of the samples regarding how immersive the virtual exhibition comparing to actual physical exhibition. 23 participants (51.1%) chose "highly immersive", 18 participants (40%) selected "immersive", and 4 participants (8.9%) voted "neutral" as shown in Table 4.

Table 4

Levels of Immersion while viewing the virtual exhibition

Likert Scale	Frequency (n=45)	Percentage (%)
Extremely not immersive	0	0
Not immersive	0	0
Neutral	4	8.9
Immersive	18	40
Highly immersive	23	51.1

4.3.4 Satisfaction level toward the virtual twin exhibition

The researcher used a Likert scale to assess the opinions of the samples regarding their satisfaction level toward the virtual exhibition. 28 participants (62.2%) chose "extremely satisfied", and 17 participants (37.8%) selected "satisfied" as shown in Table 5.

Table 5

Levels of Satisfaction after viewing the virtual exhibition

Likert Scale	Frequency (n=45)	Percentage (%)
+	0	0
Dissatisfied	0	0
Neutral	0	0
Satisfied	17	37.8
Extremely Satisfied	28	62.2

The table above indicates that the samples' satisfaction with the innovation was between satisfied and extremely satisfied.

4.3.5 Expert opinions

In order to get their thoughts on how photogrammetry was used in this research, three experts in the disciplines of art, design, and technology were invited to a structured interview session. The art expert sees this as a new medium for expression and a way to discuss and

compare exhibitions. The design expert believes that the photogrammetry-based virtual display provides an experience that is as natural to the viewer as that of a physical exhibition. Table 3 displays survey responses regarding perceived ease of use; this expert's view confirms those responses. It is possible, the technology expert adds, that this method will replace traditional methods of displaying digital replicas of tangible works of art. The virtual exhibition is a safe option for showing artwork without contracting COVID-19, according to all experts.

CHAPTER 5

CONCLUSION

The following points were revealed in light of the research findings:

5.1 THE PHOTOGRAMMETRY APPROACH TO DIGITAL RECREATION OF AN ART SCULPTURE

Due to the following constraints, the photometry scanning of the model yielded data that must be adjusted by hand.

5.1.1 This investigation was conducted inside a building with somewhat low lighting, necessitating camera settings with a wider aperture and slower shutter speed than ideal, resulting in numerous fuzzy photographs. The application may identify blurry photographs as defective. Consequently, good lighting could be useful in order to shoot photographs with sufficient light.

5.1.2 The exhibition took place in a commercial facility, therefore the research team had limited time to capture photographs. If there had been more time, the researchers could have reviewed the outcomes of past picture sessions and taken additional images.

5.1.3 There should be a device to assist in taking photographs from above the object, as several sculptures and other objects were placed quite high. Using a drone equipped with a high-resolution camera could enhance the photogrammetry process.

5.1.4 Due to space constraints, the artworks were positioned closely together. This makes it pretty difficult to photograph the work item from all sides. The results would be improved if the sculptures were separated from one another by additional space.

5.2 THE EFFICACY OF THE VIRTUAL EXHIBITION FROM PHOTOGRAMMETRY

The researchers asked the exhibition attendees to view sculptures in the virtual exhibition. Upon completion of the viewing, they were asked about their satisfaction level with the experience. The results are unanimous, as shown in Table 5: 62.2% of attendees voted highly

satisfied, while 37.8% voted satisfied. Not only was the satisfaction level voted extremely high, but 91.1% of the audience also thought the 3D sculptures within the virtual exhibition were immersive and highly immersive, as shown in Table 4.

5.3 VIRTUAL EXHIBITION FROM PHOTOGRAMMETRY AS A SOLUTION FOR THE PANDEMIC

Both the survey findings regarding viewing immersion (Table 4) and the opinions of experts show that the photogrammetry virtual exhibition can be utilized as an alternative to physically attending an art exhibition.

5.4 CONCLUSION

To create a digital model from a physical counterpart, current photogrammetry is neither entirely automatic nor accurate, but it can serve as a basis for building photo-realistic models. This research showed that photogrammetry could be done in a methodical, time-saving way that yet produced accurate findings. You need the right tools, software, and strategies to get the job done effectively. Most significantly is the quality of the photographs used for creating 3d and texturing. Hence, knowing what cameras and equipment to use, what settings to apply, and how to fix the photographs are paramount. After the model has been created using photogrammetry, it needs undergo model amendment in order to enhance its quality. The scanned models and environment can then be generated as an immersive virtual twin exhibition. During the pandemic, the virtual twin exhibition might be utilized as an alternative venue for art exhibitions that provides safety and accessibility for its audience.

5.5 RECOMMENDATIONS

Photogrammetry can be applied in a variety of situations, such as the creation of new innovations and the examination of various locales. Through geographic analysis and the examination of other photographic data, the technique can also be utilized to discover crucial information in the context of study. It can be applied to a natural region in order to investigate the alterations that have occurred throughout time.

BIBLIOGRAPHY

CapturingReality. (2022). RealityCapture - Photogrammetry Software. (n.d.). Retrieved December 12, 2022, from https://www.capturingreality.com/realitycapture

CINE Communities. (n.d.). Photogrammetry (Advanced) – CINE Communities. Retrieved December 12, 2022, from https://www.cinecommunities.org/photogrammetry-advanced/

Diez, Maximillian. (2021, Feb 1, 2021). Virtual Reality Will Be A Part Of The Post-Pandemic Built World. Retrieved From https://www.globaltimes.cn/page/202103/1219713.shtml

Guterres, António. (2020). Covid-19 crisis closes 90 percent of museums globally, UNESCO plans for reopenings. UN News. Retrieved From https://news.un.org/en/story/2020/05/1064362

M. L. Heilig: El Cine del Futuro: The Cinema of the Future. Presence, Vol. 1, No. 3, pp. 279-294 (1992)

Meydenbauer, Albrecht. (1867). Die Photometrographie. In: Wochenblatt des Architektenvereins zu Berlin Jg.

Suziedelyte-Visockiene J, Bagdziunaite R, Malys N, Maliene V. (2015). "Close-range photogrammetry enables documentation of environment-induced deformation of architectural heritage". Environmental Engineering and Management Journal. 14 (6): 1371–1381. doi:10.30638/eemj.2015.149

WHO. (2021). Coronavirus disease (COVID-19): How is it transmitted? Retrieved From https://www.who.int/news-room/q-a-detail/coronavirus-disease-covid-19-how-is-it-transmitted

Ampanwong, Suthiluk. (1994). Chang Thai. Bangkok: Matichon Publishing.

Augustyn, Adam. (2021). Bhumibol Adulyadej. Britannica. Retrieved from https://www.britannica.com/biography/Bhumibol-Adulyadej

Biography of His Majesty King Bhumibol Adulyadej. (1999). Retrieved from http://kanchanapisek.or.th/biography/hmk.en.html

Documentary of the first official visit to the United States of His Majesty King Bhumibol Adulyadej in 1960. (2016). Retrieved from https://th.usembassy.gov/vdo-remembering-king-bhumibol-adulyadejs-state-visit-u-s-1960/

Karnjanatawe, Karnjana. (2017). A monarch's vision. Retrieved from https://www.bangkokpost.com/travel/1341211/a-monarchs-vision

King Rama IX and Thai Education. (2019). Retrieved from https://www.komchadluek.net/news/402536

Land Rover Series III: From His Majesty King Rama IX's vehicle to Piggy Bank "Follow Father's Steps". (2017). Retrieved from https://www.grandprix.co.th/land-rover-series-iii-รถทรงงาน

Noble Monks and King Rama IX. (2016). Retrieved from https://mgronline.com/dhamma/detail/9590000109033

Posttoday. (2016). "Tonmai Khong Por" - The Tree Our Father Planted when His Majesty King Rama IX visited Kanchanaburi. Retrieved from https://www.posttoday.com/social/local/461110

Roxas, Joseph Tristan. (2017). Coffee at Thailand's Pha Mee village: A royal gift for a former opium plantation. Retrieved from https://www.gmanetwork.com/news/lifestyle/travel/626217/coffee-at-thailand-s-pha-mee-village-a-royal-gift-for-a-former-opium-plantation/story/

Saosawadee. (2016). "Plook Pa Nai Jai" - His Majesty's intent of Reforestation. Retrieved from https://www.bangkokbiznews.com/lifestyle/723771

Sitthisankij, Pladisai. (2007). 80 Pansa Mahamongkol. Bangkok: Bantuek Siam Publishing.

Sumamanon, Mod. (2017). Revisiting "King Rama IX and Somdet Phra Sri Nagarindra The Princess Mother" - The King of Filial Piety. Retrieved from https://today.line.me/th/v2/article/vkO9vE

Valentina, Jessicha. (2017). Learning Akha hill tribe's way of living in Pha Mee village. Retrieved from https://www.chiangraitimes.com/tourism/learning-akha-hill-tribes-way-of-living-in-pha-mee-village/

Wechsler, Maximilian. (2014). The Life and Work of His Majesty King Bhumibol Adulyadej. The BigChilli.

APPENDIX

A. HUMAN ETHICS APPROVAL

COA. No. RSUERB2021-053

Certificate of Approval
By
Ethics Review Board of Rangsit University

COA. No.	**COA. No. RSUERB2021-053**
Protocol Title	**Virtual Reality as an emerging Art Exhibition Platform in the age of Pandemic**
Principle Investigator	**Piyanon Somboon**
Co-Investigator	**Gomesh Karnchanapayap**
Affiliation	**Faculty of Digital Art, Rangsit University**
How to review	**Expedited Review**
Approval includes	**1. Project proposal** **2. Information sheet** **3. Informed consent form** **4. Data collection form/Program or Activity plan**
Date of Approval:	**16 / 07 / 2021**
Date of Expiration:	**16 / 07 / 2023**

The prior mentioned documents have been reviewed and approved by Ethics Review Board of Rangsit University based Declaration of Helsinki, The Belmont Report, CIOMS Guideline and International Conference on Harmonization of Good Clinical Practice or ICH-GCP

Signature.....

(Assistant Professor Dr. Panan Kanchanaphum)

Chairman, Ethics Review Board for Human Research

B. RESEARCH QUESTIONNAIRE

แบบประเมินการรับชมนิทรรศการ *"...ไม่ต้องจำว่าฉันคือใคร แต่จำว่าฉันทำอะไรก็พอ..."* ระหว่าง 1 พฤศจิกายน – 30 พฤศจิกายน พ.ศ. 2565
ณ หอศิลป์ Erabica Coffee 36/1 ถ.รังษีเกษม ต.ในเวียง อ.เมืองน่าน จ.น่าน 55000
งานวิจัยเรื่อง Virtual Reality as an Emerging Art Exhibition Platform in the age of Pandemic
ผู้วิจัย ผศ. ดร.โกเมศ กาญจนพาชัพ (คณะมัณฑนศิลป์ มหาวิทยาลัยศิลปากร) / อาจารย์ ปิยนนท์ สมบูรณ์ (คณะดิจิทัลอาร์ต มหาวิทยลัยรังสิต)

คำชี้แจง แบบสอบถามแบ่งออกเป็น 6 ตอน รวม 19 ข้อ

ตอนที่ 1 ข้อมูลทั่วไปของผู้ตอบแบบสอบถาม
ตอนที่ 2 การรับชมแบบ Virtual Interactive Tour ผ่านจอคอม
ตอนที่ 3 การรับชมแบบวิถีทัศน์เสมือนจริงผ่านแว่น VR
ตอนที่ 4 การรับชมแบบ 3D ความเป็นจริงเสมือนผ่านแว่น VR
ตอนที่ 5 ประเมินเปรียบเทียบการรับชมรูปแบบต่าง ๆ
ตอนที่ 6 ข้อคิดเห็น

กรุณาใส่เครื่องหมาย (✓) ใน ☐ คำตอบที่ท่านเลือก

ตอนที่ 1 ข้อมูลทั่วไปของผู้ตอบแบบสอบถาม

1. เพศ ☐ ชาย ☐ หญิง ☐ นอนไบนารี่

2. อายุ ..... ปี

ตอนที่ 2 ประเมินการรับชมนิทรรศการแบบ Virtual Interactive Tour ผ่านจอคอมพิวเตอร์

3. ความยากง่ายการรับชม Virtual Interactive Tour
☐ ใช้งานยากมาก ☐ ใช้งานยาก ☐ ใช้งาน ไม่ยากไม่ง่าย
☐ ใช้งานง่าย ☐ ใช้งานง่ายมาก

4. ความพึงพอใจต่อรูปแบบนิทรรศการ Virtual Interactive Tour
☐ ไม่พึงพอใจมาก ☐ ไม่พึงพอใจ ☐ เฉย ๆ
☐ พึงพอใจ ☐ พึงพอใจมาก

5. ความคื่มค่าเสมือนได้เข้าชมนิทรรศการจริงเมื่อชม Virtual Tour
☐ มีความคื่มค่าต่ำมาก ☐ มีความคื่มค่าต่ำ ☐ ปานกลาง
☐ มีความคื่มค่าสูง ☐ มีความคื่มค่าสูงมาก

6. ความเหมาะสมในการใช้ Virtual Tour แทนนิทรรศการจริง
☐ ไม่เหมาะสมมาก ☐ ไม่เหมาะสม ☐ ปานกลาง
☐ เหมาะสม ☐ เหมาะสมมาก

7. ข้อเสนอแนะเกี่ยวกับ Virtual Interactive Tour

ตอนที่ 3 ประเมินการรับชมนิทรรศการแบบ วิถีทัศน์เสมือนจริง

8. ความยากง่ายการรับชมนิทรรศการด้วยวิถีทัศน์เสมือนจริง
☐ ใช้งานยากมาก ☐ ใช้งานยาก ☐ ใช้งาน ไม่ยากไม่ง่าย
☐ ใช้งานง่าย ☐ ใช้งานง่ายมาก

9. ความพึงพอใจต่อรูปแบบนิทรรศการวิถีทัศน์เสมือนจริง
☐ ไม่พึงพอใจมาก ☐ ไม่พึงพอใจ ☐ เฉย ๆ
☐ พึงพอใจ ☐ พึงพอใจมาก

10. ความคื่มค่าเสมือนชมนิทรรศการจริงเมื่อชมวิถีทัศน์เสมือนจริง
☐ มีความคื่มค่าต่ำมาก ☐ มีความคื่มค่าต่ำ ☐ ปานกลาง
☐ มีความคื่มค่าสูง ☐ มีความคื่มค่าสูงมาก

11. ความเหมาะสมในการใช้วิถีทัศน์เสมือนจริงแทนนิทรรศการจริง
☐ ไม่เหมาะสมมาก ☐ ไม่เหมาะสม ☐ ปานกลาง
☐ เหมาะสม ☐ เหมาะสมมาก

12. ข้อเสนอแนะเกี่ยวกับนิทรรศการแบบวิถีทัศน์เสมือนจริง

ตอนที่ 4 ประเมินการรับชมนิทรรศการด้วย 3D ความเป็นจริงเสมือนผ่านแว่น VR

13. ความยากง่ายการรับชมนิทรรศการด้วย 3D VR
☐ ใช้งานยากมาก ☐ ใช้งานยาก ☐ ใช้งาน ไม่ยากไม่ง่าย
☐ ใช้งานง่าย ☐ ใช้งานง่ายมาก

14. ความพึงพอใจต่อรูปแบบนิทรรศการ 3D VR
☐ ไม่พึงพอใจมาก ☐ ไม่พึงพอใจ ☐ เฉย ๆ
☐ พึงพอใจ ☐ พึงพอใจมาก

15. ความคื่มค่าเสมือนชมนิทรรศการจริงเมื่อชมนิทรรศการแบบ 3D VR
☐ มีความคื่มค่าต่ำมาก ☐ มีความคื่มค่าต่ำ ☐ ปานกลาง
☐ มีความคื่มค่าสูง ☐ มีความคื่มค่าสูงมาก

16. ความเหมาะสมในการใช้ 3D VR แทนนิทรรศการจริง
☐ ไม่เหมาะสมมาก ☐ ไม่เหมาะสม ☐ ปานกลาง
☐ เหมาะสม ☐ เหมาะสมมาก

17. ข้อเสนอแนะเกี่ยวกับนิทรรศการแบบ 3D VR

ตอนที่ 5 ประเมินเปรียบเทียบการรับชมรูปแบบต่าง ๆ

18. นิทรรศการรูปแบบใดให้ประสบการณ์รับชมนิทรรศการคื่มค่าที่สุด
☐ Virtual Interactive Tour บนคอม ☐ วิถีทัศน์เสมือนจริงบนแว่น VR
☐ 3D ความเป็นจริงเสมือนบนแว่น VR

ตอนที่ 6 ข้อคิดเห็น

19. เหตุใดรูปแบบที่ท่านเลือกในข้อ 18 จึงให้ความรู้สึกคื่มค่าที่สุด

RESEARCHER BIO

Prefix	Mr.
First Name	Piyanon
Last Name	Somboon
Date of Birth	29 April 1983
Home Address	431/290 Delight The Loft, Lak Hok, Muang, Pathum Thani, 12000 Thailand
Telephone	66-85-838-5956
Work Address	Faculty of Digital Art, Rangsit University, Building 8, 52/347 Muang-Ake Phaholyothin Road, Lak-Hok, Muang Pathum Thani 12000, Thailand
Work Phone	66-2-997-2200
Email Address	Piyanon.s@rsu.ac.th

EDUCATION

Bachelor Degree

Major	Computer Art
Year of Graduation	2006
Institute	Rangsit University
Country	Thailand

Master Degree

Major	Master of Communication Arts (Film and Digital Media)

Year of Graduation	2021
Institute	Kasem Bundit University
Country	Thailand

FIELDS OF EXPERTISE

- Photogrammetry
- Virtual Reality
- New Media Art

RESEARCHER BIO

Prefix	Assistant Professor Dr.
First Name	Gomesh
Last Name	Karnchanapayap
Date of Birth	14 July 1977
Home Address	88/45 Burasiri Rangsit Bang Pa-In Pak Kred Road, Suan Prik Thai, Muang, Pathum Thani, 12000 Thailand.
Telephone	66-82-835-9853
Work Address	Faculty of Decorative Arts, Silpakorn University Wang Tha Phra Campus. 31, Na Pralan Rd., Phra Borom Maha Ratchawang, Phra Nakhon, Bangkok 10200.
Work Phone	02-221-5874
Email Address	Karnchanapayap_G@Silpakorn.edu

EDUCATION

Bachelor Degree

Major	Computer Science
Year of Graduation	1998
Institute	California State University, Fresno
Country	United States of America

Master Degree

Major	Design
Year of Graduation	2017
Institute	Rangsit University
Country	Thailand

Doctoral Degree

Major	Decorative Arts
Year of Graduation	2020
Institute	Silapakorn University
Country	Thailand

ACADEMIC PUBLICATIONS

2019 Karnchanapayap, G., Chaetnalao, A. (2019). Virtual Simulacrum: Reenacting Immersive First-Person Experience Through Virtual Reality Animation. Proceedings of International Conference on Innovative Digital (ICID2019) Bangkok, Thailand. November 21st-23rd, 2019.

2019 Karnchanapayap, G., and Chaetnalao, A. (2019). Virtual Reality Sculpting–the Quintessential Sculpting Medium of the Digital Era. International Conference, The 7th Burapha University International Conference on Interdisciplinary Research, Burapha University, Chonburi, Thailand. pp. 13-20. November 29th, 2019.

2019 Karnchanapayap, G. (2019). VR Animation: The New Transformation of Storytelling. Paper presented at IEEE VR 2019 2nd IEEE Workshop on Animation in Virtual and Augmented Environments (ANIVAE-2019) in Osaka, Japan. pp. 1-4. March 24th, 2019.

2021 Karnchanapayap, G., Chaetnalao, A. (2021). The Development of Virtual Reality as a new Buddhism learning medium. Journal of Social Science and Buddhistic Anthropology, Vol. 6. June, 2021. pp. 48-64. (Thai-Journal Citation Index TCI-1).

2021 Karnchanapayap, G., Chaetnalao, A. (2021). The Research and Development of "Enlightenment" Multi-interaction Level Virtual Reality New Media Art. Humanities, Arts and Social Sciences Studies. Volume 21, Number 2, May-August, 2021. pp. 291-310. (SCOPUS and the Thai-Journal Citation Index TCI-1).

2021 Karnchanapayap, G. (2021). The Research and Creation of Physical Art Object Through Virtual Reality. Rangsit Journal of Social Sciences and Humanities: RJSH. Volume 8 Number 2, (July - December, 2021). pp. 67-80. (Thai-Journal Citation Index TCI-1).

2021 Karnchanapayap, G., Chaetnalao, A. (2021). Virtual reality art as an innovative Buddhist learning tool. International Journal of Arts and Technology, 13(3), 255. 3. (SCOPUS Q1).

2021 Karnchanapayap, G. (2021). Virtually Real Sculpting: A Practice Based Research of Sculpting with Virtual Reality Technology, Silpakorn International Conference on Total Art and Science 2021 (SICTAS 2021), Silpakorn University, Thailand. pp.399-409. November 3rd-5th, 2021.

2022 Karnchanapayap, G. (2022). The Ministry of Digital Economy and Society's Virtual Experience—Employing Engaging Audience Activities through Virtual Reality in a Digital Technology Convention, The 8th National and International Academic Conference on Fine and Applied Arts (FAR8), Khon Kaen University, Thailand. September 3rd-4th, 2022.

2023 Karnchanapayap, G. & Somboon, P. (2023). The Research of Photogrammetry to Generate a Virtual Twin Art Exhibition of King Bhumibol Statues, International Research Conference 2023 "The King's Philosophy for Innovation and Creative Economy towards Sustainable Development Goals in the New Normal Era: Opportunities and Challenges", Buriram Rajabhat University, Buriram, Thailand. February 15th 2023.

2023 Karnchanapayap, G. (2023). Augmented Reality Enhanced NFT Arts to Raise Awareness of the Endangerment of Thai Tokay Geckos. Burapha Arts Journal. 26(1). (Thai-Journal Citation Index TCI-2).

2023 Karnchanapayap, G. (2023). Activities-based virtual reality experience for better audience engagement. Computers in Human Behavior, 107796. https://doi.org/10.1016/j.chb.2023.107796 (SCOPUS Q1)

FIELDS OF EXPERTISE

- Digital Sculpting
- Virtual Reality Sculpting
- New Media Art